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Statement of Work

PRECONCEPTUAL ENGINEERING SERVICES

for the

NEXT GENERATION NUCLEAR PLANT

with

HYDROGEN PRODUCTION

Project No. 23843

Idaho National Laboratory

The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance.

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1. GENERAL

1.1 Introduction

Battelle Energy Alliance (BEA), the Management & Operating Contractor of the Idaho National Laboratory (INL), is requesting prospective Engineering firms to provide preconceptual engineering services for the Next Generation Nuclear Plant (NGNP) prototype that will be designed to produce process heat, hydrogen and electricity. Participation in the preconceptual design activities described herein neither pre-qualifies nor dis-qualifies the participant for later design work for NGNP.

1.2 Background

The Department of Energy (DOE) has selected the INL as the lead national laboratory for nuclear energy research. Per the terms of the Energy Policy Act of 2005, Title VI, Subtitle C, Section 662, the INL, under the direction of the DOE, will lead the development of the NGNP by integrating, conducting and coordinating all necessary research and development activities and by organizing all project participants. The INL will be responsible for conducting site and project related procurements and coordinating project efforts with industry and the international community.

1.3 Overall Program Objective

As presented in the National Energy Policy, there is a national strategic need to promote further reliance on safe, clean, economical nuclear energy. In the 2003 State of the Union Address, President Bush launched a new National Hydrogen Fuel Initiative to provide domestically produced, clean-burning hydrogen to the transportation sector as an alternative to imported oil. The combination of these two objectives - to promote nuclear energy and to produce clean-burning hydrogen - can be met simultaneously with the development of new advanced reactor and hydrogen generation technology. The DOE's mission need is to develop this combined technology that will enable the continued use of secure, domestic nuclear energy and establish a greenhouse-gas-free technology for the production of hydrogen, thereby supporting both the President's agenda for a hydrogen economy and the DOE's strategic goal to promote a diverse supply of energy.

1.3.1 Energy Policy Act of 2005

In July of 2005, Congress passed the Energy Policy Act of 2005 (H.R. 6), which was signed into law by the President in August of 2005. Under Section 641, the Act states, "The Secretary shall establish a project to be known as the 'Next Generation Nuclear Plant Project'."

It continues, "The Project shall consist of the research, development, design, construction and operation of a prototype Nuclear System, including a nuclear reactor that:

- is based on research and development activities supported by the Generation IV Nuclear Energy Systems Initiative….
- shall be used to:

  generate electricity

  produce hydrogen

  or both generate electricity and produce hydrogen."

1.4 Purpose

The purposes of initiating the preconceptual design work described herein includes:

- Assisting in focusing the technical scope and priorities of research & development activities for the NGNP.

- Providing a basis for subsequent development of the technical and functional specifications for the prototype facilities for NGNP.

This Statement of Work is consistent with the Phase I scope of work defined for the NGNP Project in the Energy Policy Act of 2005. Phase I will define the initial design parameters for the NGNP, select the principal hydrogen production technology and conduct supporting research and development.

2. SUBCONTRACT SCOPE OF WORK

2.1 Preconceptual Design Report

The INL requires Engineering Services for preconceptual design work to focus and prioritize research and development work and to prepare for the Conceptual Design for the NGNP. The preconceptual design work will include evaluation of a range of design parameters and alternatives and based on the justification for the parameters and alternatives so-developed, prepare a preconceptual design for the NGNP prototype facilities. The design parameters and alternatives to be evaluated will include thermal power level, reactor inlet and outlet temperatures, primary and secondary cycle (pressures, temperatures and fluids), reactor designs (pebble bed compared to prismatic block concept), power conversion concept (e.g., direct compared to indirect cycle, power conversion machinery concept), process heat transfer and transport concepts (e.g., intermediate heat exchangers concepts, heat transport media) and hydrogen production capability. An important purpose of the evaluation of parameters and alternatives is to determine what is appropriate for the prototype to support subsequent commercialization of NGNP technologies (e.g., scaling and licensing considerations). Research and development needs and priority changes deemed necessary to select such parameters among the alternatives will be identified.

The subcontractor shall conduct concept design studies as described above to define the commercial scale prototype reactor, electrical power generation system, process heat transfer and transport systems and the hydrogen generation plant for the NGNP using very high temperature reactor technology. The subcontractor shall also provide input regarding the appropriate overall licensing strategy that should be followed for the NGNP prototype.

The preconceptual design shall establish the basic reactor geometry and layout; perform reactor physics and thermal fluids studies, heat balance and emissions calculations; provide subsystem identification and relative sizing (heat exchangers, pumps, compressors, piping, structural, etc.) including balance of plant support facilities; and provide general site layout, subsystem/plant interfaces, etc. The modular reactor design shall be based on a single module capacity. The optimal size and design temperature for the reactor type shall be determined for a "commercial scale prototype reactor" for electrical power generation, optimal hydrogen production efficiencies and other industry applications of high temperature process heat. The smallest practical hydrogen plant to demonstrate production as a commercial prototype shall be recommended. The nuclear system concept designs shall include concept design layout for the optimal sized hydrogen production plant for commercial scale demonstration for the NGNP and shall specifically address separation distance required, if any, between the nuclear reactor and the hydrogen plant, based on safety and licensing requirements. The overall nuclear system design work shall assemble current research and development, design information and information status (what is known and what is unknown) into a single report.

This work will include industry literature research on current and emerging technologies for: helium cooled very high temperature reactor technologies, hydrogen and electricity production, other industry high temperature process heat applications study, the site study at the INL, capital cost estimates, operating cost estimates, life cycle cost estimates, economic analysis and project schedule (see Sections 2.2 and 2.3 below) all at a preconceptual design level of detail.

Information from the concept designs will provide a foundation to define the next level of technical and functional requirements, provide NGNP management with important decisional information in preparation for the NGNP Conceptual Design phase and provide NGNP program management with geometric data, identification of critical Structures, Systems and Components (SSC) and data that are needed to further direct and focus planned research and development (R&D) in the areas of reactor safety and design methods, fuels, materials and licensing.

Special studies on various systems, components and/or issues, shall be conducted to focus on specific details and topics as specified in Section 6.3 below and shall be included in the final Preconceptual Design Report. The results from the special studies described under Sections 6.3 below shall be incorporated into the reactor concept designs. Additional details for the Report are given in Section 6.4 below and Report topics are given in Appendix B.

2.2 Cost Estimates

Cost Estimates shall be prepared in accordance with DOE Order 413.3 and shall at a minimum cover the following areas:

2.2.1 Capital Cost Estimates

Preconceptual design Capital Cost Estimates, based on the integrated prototype preconceptual design, shall be prepared that address: R&D, design development, design, construction, start up and testing estimates for the preconceptual design prototype nuclear system. Cost estimates shall include the estimating basis and approach for the capital cost estimates and shall break costs into direct and indirect costs. Estimated contingency shall be based on identified project risks.

2.2.2 Operating Cost Estimates

Operating Cost Estimates for a period of 30 years for the prototype preconceputal design shall be prepared that includes: labor, materials, operating and maintenance costs. Assumptions and methodology shall be documented. Estimates for fuel and fuel cycle costs shall be included.

2.2.3 Lifecycle Cost Estimates

Prepare a Lifecycle Cost Estimate based on the Prototype Preconceptual design for the Commercial Scale plant over a 60 year design life that at a minimum combines: design, construction, startup, operations, maintenance, fuel and decontamination and decommissioning costs.

2.3 Preconceputal Project Schedule

A preconceputal project schedule for the Prototype Nuclear System shall be prepared showing the: DOE Order 413.3 project and budget cycle and Critical Decision points (CD-0, CD-1, CD-2, etc.), design, bid and award, long lead items, construction, testing, operational readiness review, licensing, environmental permitting, startup, etc. This schedule shall be resource loaded with the preconceptual cost estimates for manpower, materials and critical resources for the prototype nuclear system. Yearly funding profiles shall than be prepared using this resource loaded schedule.

2.4 Economic Analysis

A preconceptual economic analysis with an emphasis on commercial viability shall be prepared. Using the above preconceptual technical cost estimates for the prototype preconceptual design (reactor with electrical, process heat, hydrogen production and balance of plant) as a cost basis prepare an economic analysis for a Commercial Scale plant. The economic analysis, required as part of the work scope, shall, at a minimum, include the expected overall plant efficiencies based on current technologies and ultimate unit costs to produce: electricity, hydrogen and process heat production. The Subcontractor shall prescribe the appropriate comprehensive economic model for this analysis.

3. DEFINITIONS

3.1 Critical Structure, System or Component (SSC)

For the purposes of this Preconceptual Design Report, critical SSCs shall at a minimum be defined as those components that are not commercially available or do not have proven industry experience.

3.2 Level of Detail for the Preconceptual Design Report

All major systems shall be conceptually identified, sized and defined down to the system level and critical SSCs shall be identified and defined down to the component level.

3.3 Preconceptual Project Schedule

The project schedule shall include key tasks/activities and milestones and all associated accomplishments down to the 3rd WBS level as defined below:

- WBS Level 1: The Level 1 item is the NGNP Project.
- WBS Level 2: Level 2 items would include, but not limited to: Project Management, R&D, Nuclear system Conceptual Design, Fuel Development, NRC Licensing, Long Lead items, Nuclear System Preliminary Final design, Plant Construction, Start up and System Operational Testing, Operations, etc.

- WBS Level 3: Only one of the above level 2 items will be described here as an example. Others are similar in nature and content. Level 3 items under Plant Conceptual Design would be but not limited to: Reactor Island, Turbomachine, Hydrogen plant, Heat Exchangers, Balance of Plant, R&D (Materials, Methods, Fuels, Heat Exchangers, etc.), Drawings, Specifications, Value Engineering, etc.

3.4 Prototype Nuclear System

The Prototype Nuclear System definition shall include the nuclear reactor island, electrical generation systems and all balance of plant support systems and facilities.

4. SUBMITTALS/DELIVERABLES

4.1. Design progress communication and correspondence (See Section 6.2).

4.2. Twenty (20) hard copies of the Draft Preconceptual Design Report for each review (See Section 6.2.10).

4.3. Forty (40) hard copies and ten (10) Compact Discs (CDs) of the Final Preconceptual Design Report. (See Section 6.4.) Electronic format on CDs shall be Adobe Acrobat pdf files, including drawings.

4.4. One (1) copy of the Final Preconceptual Design Report on CD shall be in MS Word format, with drawings in AutoCad format.

5. REFERENCE DOCUMENTS

5.1. The Referenced Documents, Codes and Standards listed below shall be used as the initial design basis for this scope of work. This information shall be utilized as necessary to complete the scope of work for the Preconceptual Design Report. References 5.6 through 5.12 are listed as guidance documents only and are not performance requirements for the execution of this work scope. It is expected as part of the work scope that a Preconceptual Design list of applicable references, codes and standards shall be completed and as additional reference materials are utilized in the Report preparation, it shall be so noted and referenced in the Report.

5.2. "Advanced Light Water Reactor Utility Requirements Document," Volume 1-Rev. 2, Volume. 2-Rev. 8, Volume 3-Rev. 8, March 30, 1999, Electric Power Research Institute (EPRI), as applicable.

5.3. "Next Generation Nuclear Plant High-Level Functions and Requirements," Idaho National Engineering and Environmental Laboratory, September 2003, INEEL/EXT-03-01163, as modified by the Independent Technology Review Group (ITRG) report, "Design Features and Technology Uncertainties for the Next Generation Nuclear Plant", Independent Technology Review Group, Phil Hildebrandt, et al., April 2004.

5.4. "Next Generation Nuclear Plant Project, Preliminary Project Management Plan," March 2006, INL/EXT-05-00952, Rev. 1.

5.5. "Site Selection Report for the New Production Reactor at the Idaho National Engineering Laboratory," Informal Report, EGG-NPR-8517, Rev. 1, July 1989.

5.6. DOE Order 413.3, "Program and Project Management for the Acquisition of Capital Assets"

5.7. DOE Order 430.1A, "Life Cycle Asset Management"

5.8. 10 CFR 830, "Nuclear Safety Management"

5.9. 10 CFR 50, "Domestic Licensing Of Production And Utilization Facilities"

5.10. 10 CFR 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants"

5.11. 10 CFR 830, "Nuclear Safety Management"

5.12. ASME NQA-1 2000, "Quality Assurance Requirements for Nuclear Facility Applications"

6. PERFORMANCE OF WORK

6.1. Work Plan

6.1.1. Develop and submit a draft work plan with the proposal (see RFP) for the scope of work described in this document to complete the Preconceptual Design Studies and Report. The work plan shall detail and describe: all activities, organizational and staffing responsibilities for various tasks, work approach, manpower, activity estimates with cost proposal, subcontractor project organization and responsibilities, activity definition work sheets and summary sheets, as well as overall plans and schedules for accomplishing individual tasks, major milestones and reporting requirements. The draft work plan shall include a proposed schedule for all pertinent activities. See attachment A for an example of a schedule showing a minimum level of detail for the work scope.

6.1.2. BEA will review the draft work plan with the proposal and provide comments within 5 working days of Subcontract award. Based on the input of BEA, the subcontractor will develop a final work plan within 10 working days after Subcontract award and conduct meetings with BEA to facilitate planning and final completion of the work plan. Notice to proceed with the work will not be given until the final work plan is approved by BEA.

6.2. Preconceptual Design Report

During the execution of the work scope the subcontractor shall:

6.2.1. Schedule

Complete the Preconceptual Design Report no later than May 10, 2007. The progress reviews and final deliverables (See Section 4.0 and 6.4) are shown on the attached Project Schedule, Appendix A. Note that the SOW schedule dates will be adjusted according to the Actual subcontract award date.

6.2.2. Kickoff Meeting

Attend a kickoff meeting within 5 working days after subcontract award with DOE-ID and BEA at the INL to discuss the scope of work, BEA work plan comments, background information, design basis and key assumptions. The Final Work Plan will be approved 10 working days after this kickoff meeting.

6.2.3. Field Inspections

Conduct field inspections as required at the INL to aid in NGNP site location studies. Understand the existing field conditions and interfaces, including existing facilities, missions and available utilities at the INL.

6.2.4. Status Review

Prepare a schedule for monthly status meetings with BEA and weekly teleconference calls of subcontractor's key personnel (Project Manager, Project Engineer and appropriate discipline lead engineers) to review status. General items for the monthly status meetings are: progress to date vs. the plan, recovery plan for activities behind schedule, status of staffing and job hour expenditures, highlight of activities in the upcoming month, support required from BEA, schedule concerns and issues, to-date costs vs. the budget, cost trends, earned value, etc. The subcontractor may propose, for approval by BEA, alternate or standard work processes and reporting methods that meet the intent of the stated schedule and cost reporting requirements. The proposed status meeting schedule shall be submitted with the Proposal and contained in the Work Plan. Status (shown as percent complete) of the tasks identified on the Work Task Summary Sheets shall be presented at the status review meetings. Work-in-progress shall be presented for interim review by BEA at these meetings.

6.2.5. Meeting Minutes and Telephone Records

Prepare meeting minutes and records of telephone conversations, between BEA and subcontractor personnel, regardless of who initiates the call. Send copies of the meeting minutes and phone call records to BEA within two working days of the meeting or call.

6.2.6. Action Item List

Maintain an individually numbered action item list showing responsibilities and completion dates. The list shall be updated, identified with the current date and distributed within two working days after action items are added.

6.2.7. Key Assumptions List

Prepare and maintain a Key Assumptions List. The list shall be updated, highlighted to denote changes, dated with the current date and distributed within two working days after adding items to the list.

6.2.8. Equipment Lists

Prepare equipment lists for facility and process equipment for use in cost estimate preparation. Long lead procurement items and recommended quality levels on the equipment shall be identified.

6.2.9. Drawings

Prepare drawings for the monthly interim status review meetings and as part of the final Preconceptual Design Report. Drawings shall include site plans, architectural layouts, utility plans, equipment layouts, critical systems sections and appropriate details. Process block flow diagrams, etc., shall be prepared as part of the final report.

6.2.10. Design Reviews

Make a presentation on the draft Report to BEA reviewers at approximately the 50% and 90% point of completion of the Preconceptual Design Report. All comments received during the reviews shall be resolved and incorporated by the subcontractor prior to the submittal of the final Preconceptual Design Report. Comments and resolutions shall be documented and submitted for inclusion in the project files.

6.2.11. Performance Requirements

Cite and reference all key information and decisional statements or data used in the preparation of the Preconceptual Design Report and document quality assurance reviews and validation prior to submittal for review.

6.2.12. Future Studies List

Prepare a list of items that are not covered in this Scope of Work, but which should be covered in future design studies or in the conceptual design phase.

6.3. Special Studies

The following special studies shall be completed and fully integrated into the Preconceptual Design Report and be based on a very high temperature reactor technology. These special studies should be initiated and completed to the extent practical prior to the integrated preconceptual design work. These special studies shall be some of the first scheduled activities, with the results presented at working meetings between the subcontractor and BEA as the design studies progress. The reports for these special studies shall be stand alone documents with intermediate reviews and shall be contained in the Preconceptual Design Report as appendices. Important areas of technology development shall be described including the recommended approach for such development and the extent to which existing information is anticipated to be utilized.

6.3.1. Reactor Type Comparison Study

Prepare a trade study based on currently available information supplemented as required by this work scope comparing the pebble bed reactor concept to the prismatic block reactor concept. Identify the most important discriminating criteria between the two concepts and provide an assessment of the important technical, operational and maintenance differences, including the important development risks for each. Discriminating criteria may include: thermal power rating, commercial scalability, licenseability, design and operational considerations (e.g., fabricability, fuel handling systems and material accountability systems), development risks, life cycle cost, nuclear safety, non--proliferation, etc.

6.3.2. Prototype Power Level Study

The vendor shall prepare a study that evaluates and recommends a power level for the NGNP prototype nuclear system, which is scaleable and meets all the necessary requirements as a “commercial” prototype and is licensable as a commercial prototype. In addition, the subcontractor shall evaluate and recommend minimum optimal prototype hydrogen plant size that will be scaleable to a future commercial scale plant.

6.3.3. High Temperature Process Heat, Transfer and Transport Study

The design features, proposed thermal cycle, required equipment and tradeoffs considered in selecting the method of transferring and transporting process heat shall be described and the basis for the selected concept(s) described. The design approach to critical equipment (e.g., heat exchangers) and media (e.g., heat transport fluid) shall be developed and described at a preconceptual level.

6.3.4. Power Conversion System Trade Study

Prepare a trade study comparing (1) direct versus indirect Brayton cycle power conversion systems and, (2) other methods of removing heat and increasing efficiency, i.e., a bottoming cycle, for use in the prototype reactor electrical production system. The study shall identify and consider important discriminating criteria and investigate the pros and cons of each. Examples of issues to be considered include technology maturity, vertical vs. horizontal shafts and bearings, maintenance issues, installation of equipment inside or out of primary pressure boundary, contamination issues, etc. Additional considerations are identified in the topical outline, Appendix B, 20.4.

6.3.5. Primary and Secondary Cycle Concept Study

Prepare a trade study for the primary and secondary cycle concept that selects and justifies system used in the preconceputal design work, which among other issues specifically addresses: the reactor inlet and outlet temperatures, primary and secondary loop system operating pressures and temperatures, the extent of contamination anticipated in the primary loop, acceptability of contamination levels for maintenance functions and the associated hydrogen production system concept.

6.3.6. Licensing and Permitting

Prepare a study that compares licensing the NGNP under 10 CFR Part 50 vs. 10 CFR Part 52. The advantages and disadvantages of each approach and the risks associated with each approach shall be included. Also, the feasibility of using Part 52 for development of an early site permit (ESP) and Part 50 for licensing the reactor facility (construction permit and operating license) shall be considered. In addition, the availability and pros and cons of using the new advanced reactor licensing framework being developed by the NRC (to become Part 53) shall be evaluated. Additionally, the feasibility of applying a "license by test" philosophy for obtaining a Nuclear Regulatory Commission (NRC) license for the NGNP demonstration facility (see Appendix B, 15) shall be evaluated.

Identify the issues and recommend an approach for licensing an integrated nuclear facility/hydrogen production plant. Identify applicable Environmental Protection Agency (EPA) and State permit requirements associated with construction and operation of an integrated nuclear facility/hydrogen production plant (see Appendix B, 15).

Develop an approach for integrating probabilistic risk assessment (PRA) methodologies early into the design process so that the reactor facility design is optimized from a safety perspective.

Integrate licensing considerations while performing Economic Assessments (Appendix B, 16) and Construction Scheduling (Appendix B, 17).

6.3.7. NGNP By-Products Study

Perform a study to identify, quantify and discuss disposition of end products produced by the NGNP and hydrogen plant. These products may include radioactive wastes, hydrogen, oxygen, waste heat, electricity, etc. Additional considerations are identified in the topical outline under Appendix B, 20.7.

6.4. Preconceptual Design Report

It is expected that the full Preconceptual Design Report will encompass multiple binders of information. This report will be used and reviewed by many organizations and management teams in preparation for and during Conceptual Design. Therefore, this report shall include two executive summary level reports, one for each reactor design. These executive summary reports shall be no longer than 100 pages in length and shall summarize the entire Preconceptual Design Report.

The final Preconceptual Design Report shall fully integrate the completed special studies, a design description of the options studied and a recommended conceptual design approach as outlined in Appendix B. The overall deliverable for this scope of work shall be a technical document entitled "NGNP and

Hydrogen Production Preconceptual Design Report," and shall be provided as an electronic file in MS Word and Adobe Acrobat formats (See Section 4.0 for a list of Subcontract deliverables).

Generally, as a **minimum**, the subcontractor shall accomplish the following at a preconceptual design level in preparing the Preconceptual Design Report:

6.4.1. Establish space allocations for general occupancy and for equipment installation, operation and maintenance.

6.4.2. Establish and quantify type of construction, significant design features, hazard classifications and occupancy ratings and define required building systems and/or utilities.

6.4.3. Identify sufficient project features to develop the cost estimate. The system design description shall describe details not specifically delineated on the drawings.

6.4.4. Identify requirements for security, containment, environmental protection, safety and industrial hygiene.

6.4.5. Identify any potential value engineering systems that should be investigated in later design phases.

6.4.6. Establish preliminary electrical one-line drawings for the "Greenfield" options that identify electrical grid connection/modification, normal, standby and emergency power. The one-line drawings shall identify the electrical grid and hydrogen plant electrical system characteristics. Investigate the capacity and interface locations of existing INL electrical systems and provide descriptions of the recommended electrical connections and power management.

6.4.7. Establish preliminary flow sheets that include waste, cooling systems, utility, mechanical and heating and ventilation (HVAC) requirements for the Nuclear System design. Identify, where practicable, flow rates, temperatures and pressures assumed for each flow stream. Determine the availability and interface locations of existing utility systems. Determine system requirements and provide descriptions of the recommended systems.

6.4.8. Evaluate facility shielding and construction options that meet DOE as-low-as-reasonably-achievable (ALARA) radiation exposure requirements. Describe, illustrate and evaluate feasible configurations for access, containment, viewing, remote equipment, decontamination, ventilation, inter-cell transfers and penetrations.

6.4.9. Evaluate computer based control and instrumentation schemes and control options and provide recommendations and supporting criteria.

6.4.10. Prepare the System Requirements Manual (SRM) for the various systems at an appropriate level of detail for a Preconceptual Design Report (generally to a System Design Description level) and to subsystem or component level for critical SSCs. Review the EPRI Utilities Requirement Document for applicability and as a basis for the SRM. The SRM shall be generally defined as the overall organization and description of the project requirements as they flow down from the: Mission Needs (MN) to Functional and Operational Requirements (F&OR) to Facility Design Description (FDD) to System Design Descriptions (SDD) to Subsystem Design Descriptions (SSDD) to System Elements (SE) to System Components (SC) to System Parts (SP).

6.4.11. Include a chapter in the preconceptual design report that presents and describes the safety case for the prototype plant. The safety case should also consider interfaces and impacts of having a hydrogen production system attached or interfacing with the nuclear system. Included is a Preliminary Hazards Assessment (PHA) to define hazard levels associated with the nuclear system, hydrogen plant and other high temperature process heat applications and associated critical systems. This assessment shall discuss the overall plant design, the associated hazards, the designed or required preventative and mitigative design features and safety systems commensurate with a preconceptual design.

6.4.12. Prepare a preconceptual heat balance for the nuclear system, hydrogen plant and other high temperature process heat systems.

7. PRECONCEPTUAL DESIGN REPORT OUTLINE

The overall deliverable for this Subcontract shall be a Preconceptual Design Report with appendices and references that contain all: special studies reports, technical models, designs, calculations, drawings, specifications, vendor data and references required to cite and document all conclusions and recommendations. The report will also be augmented with the results of the special studies listed above. Design reviews per 6.2.10 are required and modifications required to the report as a result of these reviews are the responsibility of the subcontractor.

Appendix B is a **minimum** list of issues organized in outline form that shall be addressed in the report and evaluated by the subcontractor during the course of this Preconceptual Design Report. This outline is not meant to be exhaustive but rather illustrative of the content of the design report. The subcontractor's proposal shall include a report outline that reflects, at a minimum, the items listed in Appendix B. In addition, any other issues that the subcontractor considers important shall be added and will be evaluated under the best value portion of the RFP selection criteria. It is fully expected that the organization and overall content of the Subcontractors proposal report outline will be different than that shown in Appendix B and will indicate the subcontractor's depth of understanding of the work scope and the associated technology development and systems interfaces of the NGNP.

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APPENDIX A

Proposed

NGNP PRECONCEPTUAL DESIGN SCHEDULE

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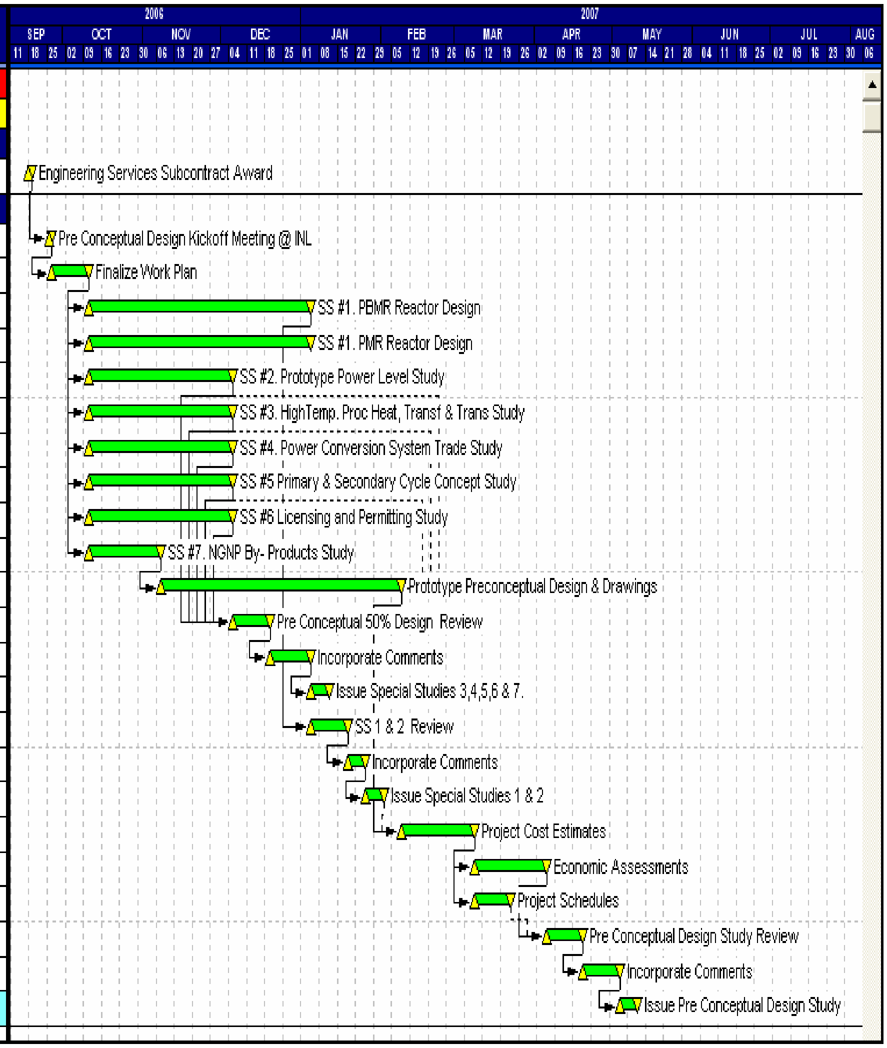
Proposed Schedule

Act ID	Description	Orig Dur	Early Start	Early Finish
NGNP Pre Conceptual Design Study				
Pre Conceptual Design				
Contract Preparation & RFP Bid Period				
MS27	Engineering Services Subcontract Award	1	18SEP06	18SEP06
Pre Conceptual Design Study Execution				
MS28	Pre Conceptual Design Kickoff Meeting @ INL	1	26SEP06	26SEP06
MS29	Finalize Work Plan	10	27SEP06	10OCT06
MS31	SS #1. PBMR Reactor Design	60	11OCT06	04JAN07
MS32	SS #1. PMR Reactor Design	60	11OCT06	04JAN07
MS33	SS #2. Prototype Power Level Study	40	11OCT06	05DEC06
MS34	SS #3. HighTemp. Proc Heat, Transf & Trans Study	40	11OCT06	05DEC06
MS37	SS #4. Power Conversion System Trade Study	40	11OCT06	05DEC06
MS38	SS #5 Primary & Secondary Cycle Concept Study	40	11OCT06	05DEC06
MS39	SS #6 Licensing and Permitting Study	40	11OCT06	05DEC06
MS45	SS #7. NGNP By- Products Study	20	11OCT06	07NOV06
MS46	Prototype Preconceptual Design & Drawings	65	08NOV06	08FEB07
MS47	Pre Conceptual 50% Design Review	10	06DEC06	19DEC06
MS48	Incorporate Comments	10	20DEC06	04JAN07
MS49	Issue Special Studies 3,4,5,6 & 7.	5	05JAN07	11JAN07
MS50	SS 1 & 2 Review	10	05JAN07	18JAN07
MS51	Incorporate Comments	5	19JAN07	25JAN07
MS52	Issue Special Studies 1 & 2	5	26JAN07	01FEB07
MS53	Project Cost Estimates	20	09FEB07	08MAR07
MS54	Economic Assessments	20	09MAR07	05APR07
MS55	Project Schedules	10	09MAR07	22MAR07
MS56	Pre Conceptual Design Study Review	10	06APR07	19APR07
MS57	Incorporate Comments	10	20APR07	03MAY07
MS58	Issue Pre Conceptual Design Study	5	04MAY07	10MAY07



NOTE: The SOW schedule dates will be adjusted according to the Actual subcontract award date.

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APPENDIX B

NGNP PRECONCEPTUAL DESIGN REPORT OUTLINE

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APPENDIX B
NGNP PRECONCEPTUAL DESIGN REPORT OUTLINE
Suggested Topics

1. SUMMARY

2. INTRODUCTION

3. OVERALL NGNP PLANT SITE DESCRIPTION

3.1. NGNP Plant Site Development

3.1.1. Land and Improvements

3.1.2. Roads, Parking and Paving

3.1.3. Utilities (Water, Steam, Air, Sanitary, Waste Water, Fire Water, etc.)

3.1.4. Transportation

3.2. Nuclear System Arrangement

3.2.1. Module Description

3.2.2. Nominal Nuclear System Performance

3.2.3. Normal Nuclear System Operation

3.2.4. Off-Nominal Operation and requirements of support facilities and systems

3.3. Balance of Plant

3.3.1. Support facilities (Medical, Fire Station, Laboratories, Offices, Warehouses, Simulator/Training Facilities, Hot & Cold Maintenance Shops, Security Systems, Etc.)

3.3.2. Power Generation Facility

3.3.2.1. Power Grid Connection

3.3.3. Hydrogen Production Plant

3.3.3.1. Transportation of Hydrogen to Industry

4. REACTOR AND REACTOR SYSTEMS

4.1. Reactor Systems (Pebble Bed and Prismatic)

4.1.1. Reactor Core

4.1.2. Reactor Internals and Hot Coolant Duct

4.1.2.1. Graphite

4.1.2.1.1. Change Out and Design

4.1.2.1.2. Side Reflector

4.1.2.1.3. Core Blocks

4.1.2.1.4. Core Supports
4.1.2.1.5. Neutron Control

4.2. Vessel Systems
4.2.1. Geometry
4.2.1.1. 3D Model
4.2.1.2. Elevation Plans
4.2.1.3. Sections
4.2.2. Reactor Size
4.2.3. Economics & Viability
4.2.4. Reactor Vessel Design
4.2.5. Cross Vessel (Hot Coolant Duct)
4.2.6. Power Conversion Vessel
4.2.7. Selection of Vessel Materials
4.2.7.1. Materials Design at Design Temperature
4.2.7.2. High Pressure Issues at Design Pressures
4.2.7.3. Applicable Codes or Needed Code Cases
4.2.8. Different vessel Affects Due to the Two Reactor Designs
4.2.9. Vessel Support Arrangement

4.3. Fuel Handling Systems
4.3.1. Fuel Handling Mechanisms
4.3.1.1. Fuel Transfer Cask Design Description
4.3.1.2. Fuel Handling Equipment Support Structure Design Description.
4.3.1.3. Fuel Handling Equipment Positioner Design Description
4.3.1.4. Local Storage Facility Design Description
4.3.1.5. Fuel Element Handling and Accountability System Design Description.
4.3.1.6. Quality Assurance

5. POWER CONVERSION SYSTEM

5.1. Cycle Operational Conditions
5.1.1. Pressures, Temperatures, Working Fluids
5.1.2. Interstage Cooling
5.1.3. Waste Heat Rejection

5.2. Components
5.2.1. Turbomachinery

5.2.1.1. Brayton Cycle

5.2.2. Heat Exchangers

5.2.2.1. Intermediate Heat Exchangers (IHX)

5.2.2.1.1. Types and Sizes

5.2.2.1.2. Materials

5.2.2.1.3. Working Fluid

5.2.3. Recuperator

5.2.4. Coolers

5.2.5. Ducting, Diffusers

6. REACTOR SUPPORT SYSTEMS AND BALANCE OF PLANT

6.1. Shutdown Cooling System

6.1.1. Shutdown Heat Exchange

6.1.2. Shutdown Circulator

6.1.3. Shutdown Cooling Control

6.2. Reactor Cavity Cooling System (RCCS)

6.3. Spent Fuel Cooling System

6.4. Nuclear Island Cooling System

6.5. Helium Services System

6.5.1. Helium Purification Train

6.5.2. Helium Transfer and Storage Train

6.6. Radioactive Waste and Decontamination System

6.7. Liquid Hydrogen System

6.8. Nuclear System Control Data and Instrumentation System

6.9. Reactor Protection System

6.10. Investment Protection System

6.11. Nuclear System Monitoring and Control System

6.12. Nuclear System Electrical System

6.13. Power Conversion Handling System

6.14. Buildings and Structures

6.14.1. Reactor Building

6.14.2. Reactor Service Building

6.14.3. Operations Center

6.14.4. Other Buildings

6.15. Nuclear Island HVAC & Contamination Control

6.16. BOP HVAC Systems

6.17. Life Safety Systems

7. MAINTAINABILITY

7.1. Maintenance Requirements for Key Systems, Vessel Systems and Components

7.2. Maintainability Assessment

7.2.1. Primary Circuit Radioactive Contamination

7.2.1.1. Direct vs. Indirect

7.2.1.2. Recommendations

7.2.2. Primary Circuit Components

7.3. Occupational Dose

7.4. Inspectability

7.5. Critical Equipment Access Requirements

8. SAFETY

8.1. Safety Features

8.1.1. Key Inherent Safety Characteristics

8.1.2. Design Provisions

8.1.2.1. Confinement

8.1.2.2. Containment

8.1.3. Safety-Related Systems, Structures and Components

8.1.4. Human Aspects.

8.2. Nuclear System Safety Assessment

8.2.1. Conduction Cooldown

8.2.2. Turbomachinery Failure Modes

8.2.3. Heat Exchanger Failure Modes

8.2.4. Hydrogen Plant Operation

8.2.5. Overall Evaluation of Safety and Licensability

8.2.6. References

9. AVAILABILITY

9.1. Turbomachinery Availability Assessment

9.2. Pebble-Bed Capacity Factor Assessment

9.2.1. Scheduled Outage Assessment

9.2.2. Forced Outage Assessment

9.2.3. Capacity Factor

9.3. Prismatic Reactor Capacity Factor Assessment

9.3.1. Scheduled Outage Assessment

9.3.2. Forced Outage Assessment

9.3.3. Capacity Factor

9.4. Long Lead Item Systems

9.4.1. Reactor Vessel

9.4.2. Intermediate Heat Exchanger (IHX)

9.4.3. Piping System Components

9.4.4. Etc.

10. REACTOR FUEL

10.1. Design and Qualification

10.1.1. Suppliers

10.1.2. Shipping/Transportation

10.1.3. Fuel Fabrication

10.2. Particle Design

10.3. Fuel Element Design

10.4. Normal Operational and Accident Fuel Testing and Qualification

10.5. Fission Product Source Term Testing and Qualification

10.5.1. Waste Management and Recycling

10.5.1.1. What will be generated?

10.5.1.2. How will it be managed?

10.5.1.3. Interim Storage

10.5.1.4. Long Term Storage

10.5.1.5. Final Disposition

11. REACTOR COMPLEXITY, ISSUES AND RISKS

11.1. Pebble Bed

11.2. Prismatic

11.3. Risks

11.4. Etc.

12. REACTOR SIMULATOR

- 12.1. Simulator Design Requirements
- 12.2. Simulator Design
- 12.3. Simulator Operations

13. HYDROGEN PLANT

- 13.1. Hydrogen Plant Requirements
  - 13.1.1. Plant Size – Spacing
  - 13.1.2. Operational Requirements
  - 13.1.3. Purity Requirements
  - 13.1.4. Safety Requirements
- 13.2. Production Technology Options/Issues
  - 13.2.1. High Temperature Electrolysis
  - 13.2.2. Thermochemical Cycles (S-I, Hybrid-S)
  - 13.2.3. Scaling Issues for Production Methods
  - 13.2.4. Hydrogen Plant risks
    - 13.2.4.1.1. Technology
    - 13.2.4.1.2. Cost, schedule
  - 13.2.5. Availability, Startup, Shutdown, Operation Characteristics
  - 13.2.6. Etc.
- 13.3. Intermediate Heat Transfer Loop
  - 13.3.1. Efficiency
  - 13.3.2. Cost
  - 13.3.3. Working fluids
  - 13.3.4. Safety
  - 13.3.5. Etc.
- 13.4. Balance of Hydrogen Plant
  - 13.4.1. H_2, O_2 storage and handling
  - 13.4.2. Chemical, storage
  - 13.4.3. On site storage
  - 13.4.4. Distribution
- 13.5. Schedule for Development
- 13.6. Production Unit Cost of Hydrogen

14. OVERALL NUCLEAR SYSTEM OPERATION

14.1. Nuclear System Performance

14.1.1. Design Point

14.1.2. Performance Uncertainties

14.2. Operating Modes

14.2.1. Philosophy of Nuclear System Operational Control

14.2.2. Operating Modes

14.2.3. Reactor / Hydrogen Plant Inter-Dependencies

14.3. Transient Operation and Control

14.3.1. Bypass Valve System

14.3.2. Turbomachinery Speed

14.3.3. Hydrogen Plant

14.3.4. Helium Inventory System

14.3.5. Reactor Power

14.3.6. Core Outlet Temperature

14.4. Waste Stream

14.4.1. Identification of Nuclear System Waste Streams.

14.4.2. Waste Stream

14.4.2.1. Elimination

14.4.2.2. Reduction

14.4.2.3. Disposal

15. LICENSING AND PERMITTING

15.1. Licensing under Part 50 vs. Part 52

15.2. Feasibility of Mixed Licensing Approach (Part 52 ESP and Part 50 CP/OL)

15.3. Feasibility of Using New Advanced Reactor Licensing Framework (to become Part 53)

15.4. Practicality of “License By Test” Licensing Method

15.5. Licensing of an Integrated Nuclear Power/Hydrogen Plant

15.6. Method for Integration of PRA Techniques During Design Phase

15.7. EPA/State Permits for Integrated Nuclear Power/Hydrogen Plant

16. ECONOMIC ASSESSMENTS

16.1. Nuclear System Capital Cost Estimate

16.1.1. Methodology, Basis and Assumptions

16.1.2. R&D Costs

16.1.3. Design Development (Conceptual Design)

16.1.4. Design

16.1.5. Construction

16.1.6. Startup and Testing

16.2. Risks for each Reactor Design

16.2.1. R&D

16.2.2. Schedule

16.2.3. Commercialization

16.2.4. Licensing

16.2.5. Codification

16.2.6. Design

16.2.7. Construction

16.2.8. Operational

16.2.9. Maintenance

16.2.10. Costs

16.2.11. Etc.

16.3. Operating Cost for the Reactor Design

16.3.1. Economic Assumptions and Methodology

16.3.2. Capital Costs

16.3.3. Operating and Maintenance Costs

16.3.4. Fuel Cycle Costs

16.3.5. Decommissioning

16.3.6. Nuclear System Development Cost

16.4. Life Cycle Costs for each Reactor Design

16.4.1. Life Cycle Costs Over the Design Life of the Reactor

16.4.1.1. R&D

16.4.1.2. Design

16.4.1.3. Construction

16.4.1.4. Startup and Testing

16.4.1.5. Operations and Maintenance

16.4.1.6. Fuel and Fueling costs

16.4.1.7. D&D

16.5. Commercial Economic Viability Analysis
16.5.1. Electricity Production Economics
16.5.1.1. Electricity costs and Temperature (Turbine Efficiencies)
16.5.2. Hydrogen Economics
16.5.2.1. Temperature Range required for Economic Viability
16.5.2.2. Cost of Hydrogen vs. Temperature
16.5.2.3. Cost per Unit of Production for:
16.5.2.3.1. High Temperature Electrolysis
16.5.2.3.2. Thermo-Chemical
16.5.2.3.3. Mixed Processes
16.5.2.3.4. Calcium Bromine Process
16.5.3. Economics & Peak Oil

17. PROJECT SCHEDULE
17.1. R&D
17.2. Conceptual Design
17.3. Design
17.3.1. Licensing (construction permit/operating license)
17.3.2. Long Lead Systems Procurement
17.4. Construction
17.5. Start-Up and Testing
17.6. Operation/Demonstration
17.7. Commercialization
17.8. Key Milestones
17.9. Critical Path Analysis

18. SAFEGUARDS AND SECURITY

19. RESEARCH AND DEVELOPMENT
19.1. R&D to Support Reactor Design, Fabrication and Construction
19.2. R&D to Support Reactor Start-Up
19.3. R&D to Support Demonstration/Commercialization
19.3.1. Safety and Operational Performance Testing
19.3.2. Contamination

- 19.3.3. Human-Machine Interface
- 19.3.4. Hydrogen Production Efficiencies
  - 19.3.4.1. Electrolysis
  - 19.3.4.2. Thermo-Chemical
  - 19.3.4.3. Operation and Control
  - 19.3.4.4. Safety
- 19.3.5. Instrumentation and Controls
- 19.3.6. Modification to Direct Power Conversion
- 19.3.7. Training
- 19.3.8. Nuclear System Safety Margins
- 19.3.9. Protection Concepts
- 19.3.10. Advance Control Room Designs
- 19.3.11. Flexible Design Requirements due to R&D Requirements

19.4. High Temperature Materials for Reactor Systems (Piping, Valves, Vessels, Etc.)

- 19.4.1. High Temperature Mechanical Properties in Air and Impure Helium (He) Environments
  - 19.4.1.1. Tensile
  - 19.4.1.2. Creep
  - 19.4.1.3. Fatigue
  - 19.4.1.4. Low and High Cycle
  - 19.4.1.5. Stress-Rupture
  - 19.4.1.6. Fracture toughness
- 19.4.2. High Temperature Environmental Degradation Processes
- 19.4.3. Long-Term Irradiation Effects and Alloying Element Activation
- 19.4.4. Thermal Aging Effects
- 19.4.5. Carbon-Carbon Composites
- 19.4.6. Ceramics

19.5. Instrumentation

- 19.5.1. High Temperature Materials Monitoring
- 19.5.2. Control Systems
- 19.5.3. Reporting Systems

19.6. Materials Outline Specifications

- 19.6.1. Reactor Island
- 19.6.2. Electrical Power Generation Interface
- 19.6.3. IHX

19.6.4. Hydrogen Plant

20. SPECIAL STUDIES

20.1. Reactor Type Comparison Study

20.1.1. Important Discriminating Criteria and Considerations

20.1.2. Reactor Type Pros and Cons

20.1.2.1. Pebble Bed Modular Reactor

20.1.2.2. Prismatic Modular Reactor

20.1.3. Specific Considerations

20.1.3.1. Wearing and Dusting

20.1.3.2. Fabrication

20.1.3.3. Motion/Flow Issues During Operation

20.1.3.4. Motion/Flow During a Design Basis Earthquake

20.1.3.5. Fuel Handling Mechanisms

20.1.3.6. Methods Development Consideration in the Pebble Movement, Shifting, Tracking, Mixing, etc.

20.2. Prototype Power Level Study

20.3. High Temperature Process Heat, Transfer and Transport Study

20.3.1. Working fluid

20.3.1.1. Gases

20.3.1.2. Liquid salts

20.3.1.3. Others

20.3.2. High Temperature Materials effects

20.3.3. Heat transfer Efficiency

20.3.4. “Leaks”

20.3.4.1. Tritium and Other Impurities

20.3.4.2. Welds

20.3.4.3. Collection of Tritium and Other Impurities

20.3.5. Market/Industry Leader/Supplier

20.3.6. Code Qualification

20.3.7. IHX Design

20.3.7.1. Shell and Tube

20.3.7.2. Compact

20.4. Power Conversion System (PCS) Trade Study

20.4.1. High Efficiency PCS Configuration Options
- 20.4.1.1. Direct vs. Indirect
- 20.4.1.2. Direct Power, Indirect Helium (He)
- 20.4.1.3. Distributed vs. Integrated
- 20.4.1.4. Vertical – Horizontal TM
- 20.4.1.5. Maintenance Implications
- 20.4.1.6. Contamination Issues

20.4.2. Cycle Operational Conditions
- 20.4.2.1. Pressures, Temperatures, Working Fluid
- 20.4.2.2. Interstage Cooling

20.4.3. Components
- 20.4.3.1. Turbomachinery
- 20.4.3.2. High Temperature Intermediate Heat exchangers
  - 20.4.3.2.1. Recuperator
  - 20.4.3.2.2. Coolers
  - 20.4.3.2.3. Ducting, diffusers

20.4.4. Important Considerations for the Program Decision Process
- 20.4.4.1. Extent of Industry Knowledge
- 20.4.4.2. Industry’s Prioritization
- 20.4.4.3. Industry’s Recommended Research and Development

20.4.5. Silver fission Product
- 20.4.5.1. High Temperature Silver Escape from Kernel Containment
- 20.4.5.2. Fission and Other Activation Products
- 20.4.5.3. Uncertainties
- 20.4.5.4. Decontamination

20.4.6. Low Risk Conversion Capability
- 20.4.6.1. Based on the Turbine and How to Achieve, What are the Requirements and Why.
- 20.4.6.2. Compressor
- 20.4.6.3. Maintenance
- 20.4.6.4. Configuration
- 20.4.6.5. Indirect/Direct Cycle
  - 20.4.6.5.1. Design features that provide the ability to convert from an indirect power conversion system to direct power conversion system at a latter date.

20.4.7. Capital and Life Cycle Costs

20.4.8. References

20.5. Primary and Secondary Cycle Concept Study

20.6. Licensing and Permitting Study

20.7. NGNP By-Products Study

20.7.1. Hydrogen Purity and Affect on Intermediate Heat Exchanger (IHX)

20.7.2. Hydrogen Production at Different Reactor Sizes

20.7.3. Potential Impacts to NGNP Sizing

20.7.4. How much and what to do with products generated (potential customers), market value and how to manage.

20.7.4.1. Electricity

20.7.4.2. Hydrogen

20.7.4.2.1. Fuel Cells

20.7.4.2.2. Production users

20.7.4.2.3. Automobile

20.7.4.2.4. Industry

20.7.4.3. Process heat

20.7.4.4. Chemical recycle

20.7.4.5. Oxygen

20.7.4.6. Tritium

20.7.4.6.1. Materials to isolate

21. SUPPORTIVE SIZING AND MISC. CALCULATIONS.

21.1. Reactor Facility

21.2. Power Generation Facility

21.3. Hydrogen Plant

21.4. Balance of Plant Facilities

22. PROJECT CRITERIA

22.1. Requirements

22.2. Design Codes

22.3. Design Life